ample, he cites the Clean Air Act standards for toxic air pollutants. They are based on the levels that industry can feasibly achieve, but Graham argues that these chemicals lead to a minuscule rise in the risk of cancer, and so according to cost-effectiveness analysis, the regulations aren't justified.

"I think it's a disagreement about whether or not the analysis tools that my field represents—risk analysis, cost-effectiveness analysis, cost-benefit—are only tools to oppose regulations," Graham says. "I happen to believe that the tools can work constructively in both ways."

That claim is being tested as Graham implements his vision for the office he now heads. One of his first moves was to require that letters to agencies and other documents about proposed regulations be posted on OIRA's Web site, a step welcomed even by his critics. In drafting the office's annual report, Graham asked the public to note outdated regulations; he received 70 suggestions that his office is now looking into. Graham has sent some rules back for more work, such as an EPA regulation requiring cleaner engines in boats and snowmobiles that, he wrote, needed "improved analysis" of the costs and benefits. He's added new slots for scientists to his office staff, now mostly economists. And in a first for OIRA, Graham has recommended two new regulations to agencies—labeling foods that contain trans-fatty acids and putting defibrillators in workplaces, both of which would clearly save lives.

Graham is emphasizing a Clinton-era executive order that recommends that agencies conduct a cost-benefit analysis for the 100 or so rules each year that cost more than $100 million (*Science*, 5 October, p. 32). He is also urging agencies to use outside experts to review both risk assessments and cost-benefit analyses for these rules. "It's plainly a delaying tactic, and it's worse. It's an abuse of science," says economist Wesley Warren—an OMB official in the Clinton Administration now with NRDC—who questions whether panels will be objective.

Other experts agree with Graham that economic analyses often need more scrutiny. "They're of extremely heterogeneous quality," says Robert Stavins, a Harvard economist who chairs the environmental economics subcommittee of EPA's Science Advisory Board. And when they have been done, these analyses have tended to vary widely across agencies on matters such as the value of a human life, he notes, making it hard to compare, say, an EPA regulation with one from the Department of Transportation.

EPA, which has already been beefing up its economic reviews, is not complaining. Under EPA administrator Christine Todd Whitman, the agency's programs are now funneling all reviews through a central economics review office. The reforms may have more impact at OSHA. The agency now tends to rely on public hearings where witnesses are cross-examined to catch problems with its analyses.

In practice, there are limits on how much influence Graham can wield. Under the executive order, OMB has to review regulations within 60 to 90 days, and if it delays some rules by sending them back for more review, OIRA may bump up against court-ordered deadlines. And some laws—governing water and air pollution and pesticides in foods, for example—require regulations to be based on health standards, so they can't be overruled with economics. Still, many other regulations aren't tied to deadlines, says former EPA official Goldman. "The ability to delay action, that is real power," she says.

Some risk analysts who sympathize with the environmentalists say it's time for them to join the debate over cost-benefit analysis instead of trying to make it go away. "This is not a Reaganite plot. It's the way business is done," says toxicologist Ellen Silbergeld of the University of Maryland, Baltimore, who's worked with Environmental Defense but declined to sign a letter opposing Graham. Graham is a "worthy opponent," and "the most important thing is for the environmental community to take this [cost-benefit analysis] on." –JOCELYN KAISER

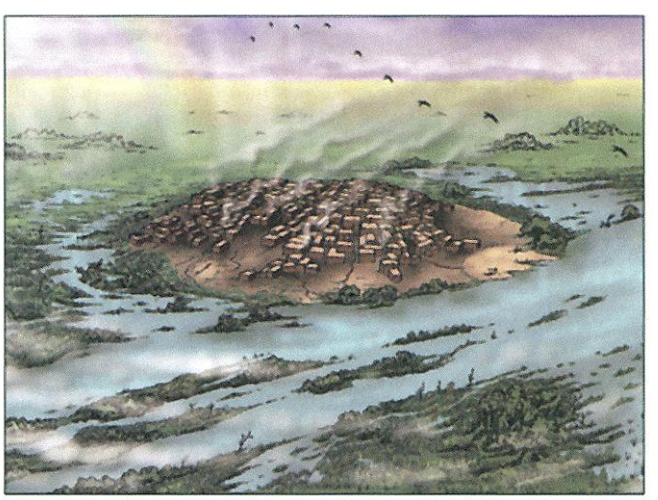
ARCHAEOLOGY

Did Plaster Hold Neolithic Society Together?

Recent studies around a 9500-year-old settlement suggest it was built in the middle of marshland. How then did its inhabitants grow their food?

ÇATALHÖYÜK, TURKEY—Sometimes the sun burns so brightly over the Anatolian plateau that it gets too hot to concentrate. Yet one sweltering day last summer, Neil Roberts had no trouble holding the attention of two dozen archaeologists crammed into the stifling conference room in the dig house at Çatalhöyük—the site of a 9500-year-old Neolithic village in south-central Turkey long regarded as one of the most important and enigmatic early settlements yet discovered. With a fan going full blast and the windows open to catch the light breeze off the surrounding wheat fields, Roberts, a geographer at the University of Plymouth in the United Kingdom, was describing some startling findings: At the time of its occupation, Çatalhöyük was smack in the middle of marshy wetlands, a stark contrast to the comparatively arid conditions that exist there today. Indeed, Roberts said, the wetlands immediately surrounding the village were probably flooded 2 or 3 months of the year.

Roberts's talk was not the only one that had the site's archaeologists scratching their heads. Data from the past 8 years of excavations at Çatalhöyük are again prompting a reassessment of this center, once home to perhaps 5000 or more people (*Science*, 20 November 1998, p. 1442). Çatalhöyük's farmers were pioneers of the so-called Neolithic Revolution in the Near East, when the hunter-gatherer lifestyle gave way to sedentary cultivation of plants and domestication of animals. During much of the last century, archaeologists thought that the rise of agriculture required early farmers to settle down so they could be near their crops and animals. Yet the new findings suggest that Çatalhöyük was inconveniently far from fields and flocks: Microscopic analysis of cereals consumed at the settlement indicates that the abundant wheat and barley were not grown in a wet alluvial landscape, but in drier, well-drained soils, the nearest of which were at least 12 kilometers away. And where did the sheep and

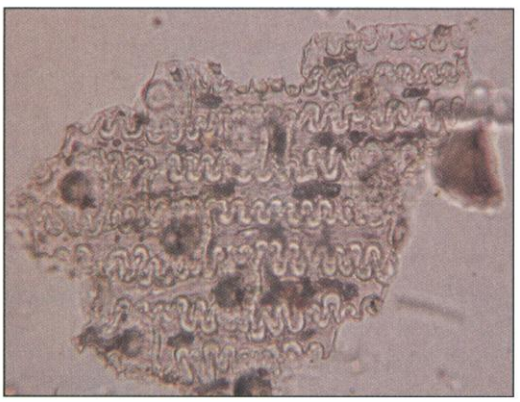


Marooned. New data suggest that Çatalhöyük was flooded during the spring, as shown in this artist's reconstruction.

CREDIT: JOHN SWOGGER/ÇATALHÖYÜK RESEARCH PROJECT

goats—whose bones are ubiquitous at the site—graze during the wettest months? Were they also tended far from the site?

To explain this puzzle, some members of the team have suggested that the tightly packed village might have been the nucleus for a more far-flung network of people and activities, and that some of its population might not have lived on the central site all year round. Other team members are not so sure. But they do agree that settling right in the middle of a floodplain was probably not the best way to ensure a daily subsistence. "Economic factors may not have been the main draw for the initial settlement of the site," says University College London (UCL) archaeologist Arlene Rosen.



Silica skeleton. These wheat cells were probably grown on dry land.

Instead, says dig director Ian Hodder, an archaeologist at Stanford University in California, the real draw of the wetlands might have been the abundance of lime-rich clays that the people of Çatalhöyük used to cover their walls, floors, and ovens—and on which they created stunning works of art. Hodder, along with other archaeologists who share his belief that noneconomic factors are key to understanding the Neolithic Revolution, has long argued that such shared symbolic expression—including religious beliefs—might have been the original glue that held early settlements together.

Water, water, everywhere

The evidence for Çatalhöyük's wetland environment is based on recent paleoecological studies by Roberts and his co-workers in the region, a large basin stretching south and east of the modern city of Konya. This area was once covered by a huge lake, but by 12,000 years ago the lake had dried out, leaving marshlands behind. About 2000 years before Çatalhöyük's founding, trees including oak and juniper gradually sprouted in the foothills nearest the site, although the immediate surroundings remained largely treeless. Just before the settlers arrived some 9500 years ago, the Çarşamba River, part of which once ran right next to the site, began depositing the broad alluvial sediments that testify to the existence of annual flooding.

This wetlands scenario receives strong support from bird bones found at the site and analyzed by zooarchaeologist Nerissa Russell and ornithologist Kevin McGowan, both at Cornell University in Ithaca, New York. They concluded that 75% to 80% of the species were water birds, such as ducks, geese, and coots. "The birds are pretty consistent" with Roberts's environmental model, Russell says. From the variety of waterfowl species found, the pair concludes that there was standing water near the settlement all year round, including marshland and a lake.

Çatalhöyük might not be alone among Neolithic communities situated in marshland. In 1995, Curtis Runnels of Boston University and Tjeerd van Andel of Cambridge University noted in the journal *Antiquity* that several Greek Neolithic sites had been located on floodplains, perhaps because they stored water in the ground after spring floods. Runnels believes that the findings at Çatalhöyük confirm these views. "The Neolithic expansion into Anatolia was pushed by a search for an ideal combination of water and agricultural land," he says.

But although Çatalhöyük's farmers certainly settled near water, they might not have been farming the wetlands, but drier land many kilometers away. Evidence for this comes from analysis of microscopic fossil plant remains, called phytoliths, carried out by Rosen. Phytoliths are formed when silica, which enters plants from the soil, is deposited within the cells of a plant's epidermal tissue. Just how much silica is deposited depends on factors such as the nature of the soil and the amount of water the plant is exposed to. For example, when wheat is grown in irrigated fields with clay-rich alluvial soils, the longer exposure to silica from standing water leads to extensive phytolith formation, and large clusters of silicified cells often form. But when wheat is grown under dry farming conditions, the phytoliths usually consist of single cells or small clusters.

Although Rosen cautions that her analysis of wheat and barley phytoliths at Çatalhöyük is still preliminary, the results so far show that most contain relatively few silicified cells. This finding "is largely consistent with the dry-farmed data," Rosen says, adding that the "maximum numbers of silicified cells per phytolith do not come anywhere close to that seen in … irrigated, fine-grained alluvial soils." Roberts's data indicate that the nearest land suitable for dry farming was 12 kilometers away.

But some experts reject the implication that Çatalhöyük's farmers were cultivating distant fields. "A model suggesting that all the cereals were grown at a great distance is slightly difficult to entertain," says UCL archaeobotanist Gordon Hillman. "The quantities of these agricultural products would be huge and would have to be [transported] to and fro."

On the other hand, Hillman does accept evidence accumulated by Eleni Asouti, also an archaeobotanist at UCL, showing that most of the wood used on the site for construction and fuel was oak and juniper. These trees would also have grown no closer than 12 kilometers from Çatalhöyük—clear proof that the villagers somehow transported materials such distances. Roberts and Rosen suggest that they might have used reed boats to transport crops and wood. Indeed, Rosen and other archaeologists working at the site have found plenty of evidence that reeds were used to make baskets and rope.

Neolithic network

This evidence that Çatalhöyük's settlers were growing food and gathering resources far from their densely populated mud-brick village has led Roberts and Rosen to propose that the settlement was at the center of a wide network. "What had previously been assumed about the first Neolithic farmers was that they lived year round in nucleated villages and exploited small areas of land," Roberts says. "Çatalhöyük was largely thought to fit this model." But it now appears, says Rosen, that "not everybody was [living in the village] all year round." For example, shepherds and farmers might have spent part of the year living away from the site, although there is no evidence of other permanent Neolithic settlements in the vicinity. "This suggests people were camping and per-

Plaster symbols. Artworks such as these painted leopards were sculpted from abundant, readily available local clay.

CREDITS: (TOP TO BOTTOM) ARLENE M. ROSEN/ÇATALHÖYÜK RESEARCH PROJECT; ÇATALHÖYÜK RESEARCH PROJECT

haps living in tents," Roberts says.

Hodder is more circumspect. "I can accept that sections of the community, perhaps unmarried young men, were living away in shelters and looking after crops," he says. "But I could not accept a model in which there were whole chunks of the community living away. There is no evidence for that, and it would not fit with the type of social system we see here. It is highly structured, integrated, and cohesive."

As for what made the community so cohesive, Hodder believes the answer lies in the lime-rich marl clays used to make plaster—the "canvas" on which Çatalhöyük's artists created their imaginative works. It was this shared symbolic expression, Hodder believes, that held the community together.

The most accessible supply of this clay, Hodder notes, would have been in the marshy floodplain, where the alluvial deposits above the marl were thinnest and "getting to the marl [would be] easier." Roberts's team has found a number of pits, dating from the Neolithic period, dug into this marl just off-site—an indication that the villagers were quarrying. And there is considerable evidence that plaster was essential to life at Çatalhöyük. Inside the mud-brick houses, almost every surface was carefully plastered with annual coats, with special care taken on the walls and on long platforms under which the bones of the settlers' ancestors were buried. On many of the walls, fantastic paintings of hunting scenes, vultures, and leopards have been found over the years of excavation, as well as plaster sculptures of bulls' heads and what some have interpreted as depictions of goddesses. "They were plaster freaks," Hodder says.

This explanation does not appeal to everyone, however. "While economic factors always seem a little inadequate to explain ... a site as interesting as Çatalhöyük," comments Runnels, "Neolithic peoples first had to secure a dependable supply of food before they could concentrate on ritual practices." Runnels adds that the Greek early Neolithic sites he has studied "made little or no use of decorative plaster, so I cannot accept the idea that plaster sources for ritual were an important component for determining early Neolithic settlement patterns."

More excavations—which are expected to continue for many years—could explain just why the founders of Çatalhöyük chose to build their village in the midst of rising waters. But if past experience is any guide, they might also turn up a whole host of new and fascinating enigmas. **–MICHAEL BALTER**

EVOLUTIONARY GENOMICS

The Ups and Downs of Evolution

ATAMI, JAPAN—Some 200 geneticists came together last month in this hot springs resort in the foothills of Mount Fuji to celebrate the 70th birthday of renowned evolutionary geneticist Masatoshi Nei. Born and educated in Japan, Nei has spent more than 30 years at U.S. universities, most recently Pennsylvania State University, University Park, and has trained many of the scientists making presentations here. In addition to conveying their appreciation, participants discussed cancer genes, speciation, and the impact of replication timing on genetic fidelity.

BRCA1's Role as Cancer Agent

Mutations in the *BRCA1* are thought to be the most common predisposing factor in familial breast and ovarian cancer. Now geneticist Simon Easteal and Gavin Huttley of Australian National University (ANU) in Canberra, John Hopper of the University of Melbourne, and Deon Venter of the Murdoch Children's Research Institute in Melbourne report that *BRCA1* mutations may also be involved in nonfamilial forms of breast and ovarian cancer, which are much more common. The results may eventually help screen for women who have an increased risk of developing breast cancer, and they could also have implications for future therapies.

The finding grew out of work on the evolutionary characteristics of *BRCA1*, a large gene known to be involved in DNA-repair and cell-cycle regulation and other processes. The ANU group had previously reported that in several primate species, the gene is frequently altered by mutations that cause one amino acid to be replaced by another. Because such amino acid substitutions indicate that natural selection has acted on a gene, the finding suggested that the cancer susceptibility associated with mutations of *BRCA1* may be a byproduct of human adaptive evolution.

With the link between familial cancer and mutations at single locations well established, Easteal and his colleagues went looking for interactions between DNA sequence variations (polymorphisms) at several different sites. They zeroed in on two *BRCA1* sites that showed strong indications of being the target of natural selection. By comparing these regions of the gene with their counterparts in other primate species, they determined that one of the polymorphisms, which they dubbed the ancestral state, had been conserved and that one, which they called the derived state, had changed significantly.

Using the health histories and genetic profiles of participants in the Australian Breast Cancer Family Study (*Science*, 19 June 1998, p. 1831), the researchers went on to show that women with nonfamilial breast cancer had a higher incidence of the ancestral state at one locus and the derived state at the other. Conversely, members of the control population, who did not have breast cancer, were more likely to have either derived states at both loci or ancestral states at both.

"We conclude that interaction between haplotype variants contributes to breast cancer risk," Easteal says. "I think that this is the first time interactions between such variations have been identified as contributing to a disease state," he adds, noting that it's not clear how the interactions increase susceptibility to breast cancer.

Audience members were hungry for more details, in particular the sizes of Easteal's control and case samples and the degree of increased risk to women carrying mixes of the haplotypes. There were 86 cases and 89 controls, Easteal explained later. And the effect "is small but significant. The full picture will be revealed when the study is published," he promised.

Despite having only part of the picture, "it was exciting stuff," says

CREDIT: PENNSYLVANIA STATE UNIVERSITY

Birthday boy. Masatoshi Nei is still going strong at 70.